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ABSTRACT FOR ORAL/ POSTER PRESENTATION : ____ORAL_____

Role of Surface States on the Sensing Properties of $In_{0.5}Ga_{0.5}As$ Surface Quantum Dots.

M.J. Milla[1], I. Hernández[2], J. Mendez[2], Jorge M. Garcia[3] and A. Guzmán[1].

[1] Instituto de Sistemas Optoelectrónicos y Microtecnología (ISOM), Madrid, Spain. [2] Instituto de Ciencia de Materiales de Madrid (ICMM – CSIC), Spain. [3] MBE Lab, IMM-Instituto de Microelectrónica de Madrid (CNM-CSIC), Spain.

Self-assembled uncapped III-V semiconductor quantum dots (QD) have recently emerged as good candidates to develop sensor devices due to their exceptional sensitivity to changes in the surrounding environment[1]. Previous studies report that the external ambient conditions greatly influence the optical and electrical properties of $In_{0.5}Ga_{0.5}As$ surface QD (SQD)[2]. Furthermore, it was found different electrical response depending on the two- or three-dimensional nature of the surface. Surface quantum well (SQW) conductivity suffers a negligible variation when changing the external atmosphere, whereas SQDs conductivity shows a significant increment[3]. Surface states are generally proposed to be responsible for such effect, although this is still under discussion[4]. In the case of the SQDs, this effect is enhanced by the high surface to volume ratio compared to SQWs.

In this work, we perform a correlation between the macroscopic and microscopic electrical properties of both nanostructures under controlled atmosphere conditions. The samples, grown by molecular beam epitaxy (MBE), are macroscopically characterized by means of I-V measurements. Likewise, we perform scanning tunnelling spectroscopy (STS) to estimate the local density of surface states. We demonstrate that the surface states are the key parameters which determine the sample sensitivity. These localized states act as trapping centers degrading the electrical properties of the sample. The passivation of such states by molecule adsorption reduces the density of active centers, and consequently, improves the surface conductivity.

In particular we compare the I-V characteristics of two $In_{0.5}Ga_{0.5}As$ nanostructures, SQW and SQDs, under different relative humidity (RH) conditions. Figure 1 illustrates the surface conductivity (SC) at -1.5V bias as a function of the RH. It can be observed an increment of one order of magnitude in the SC with the RH in case of SQD sample whereas SQW does not show any noticeable variation. This perfectly matches with the results obtained by the STS technique showing a clear reduction in the density of unoccupied surface states with the increasing water coverage (see figure 2). The high correlation between the micro- and macroscopic electrical properties points to the density of surface states as crucial for the sample sensitivity. The enhancement of such sensitivity due to the large surface to volume ratio of $In_{0.5}Ga_{0.5}As$ SQDs makes these structures very well-suited for the development of sensor devices.

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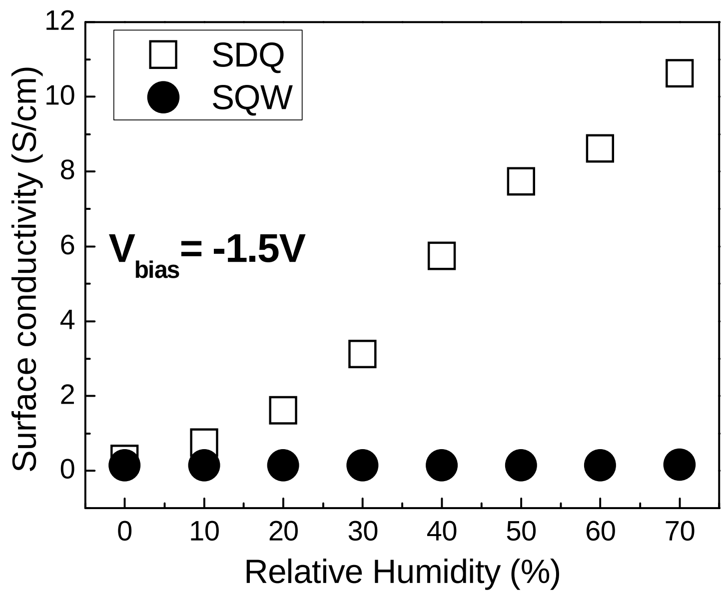

Figure 1. Variation of the surface conductivity as a function of the relative humidity in the environment. Macroscopically, SC of SQD enhances more than one order of magnitude when increasing the RH, whereas SQW keeps nearly unalterable.

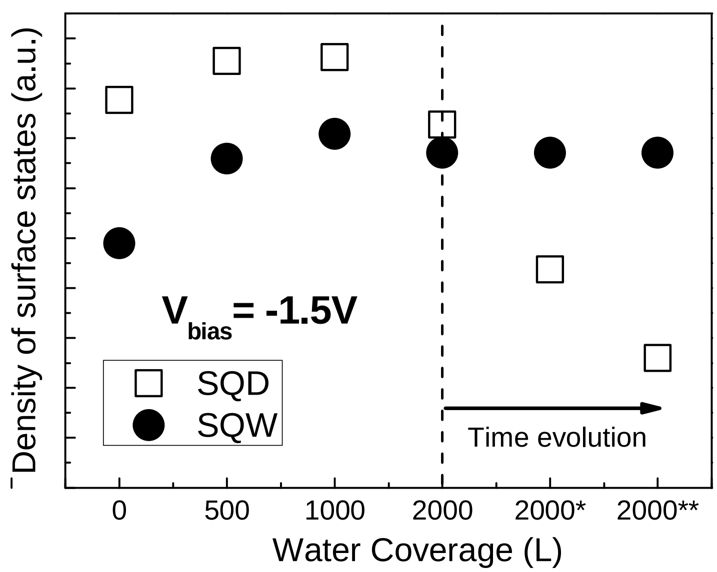

Figure 2. Variation of the density of unoccupied surface states as a function of the water coverage in Langmuir (L). Increasing the water coverage yields to a reduction of the density of surface states in SQD sample, whereas they remains nearly constant in the SQW sample. 2000* and 2000** denote longer time exposure to the 2000 L water coverage.